



POST PELLET LIQUID APPLICATION SYSTEMS

Types of Systems

The ideal liquid application system would expose each pellet to the proper amount of liquid by weight with a 360-degree uniform coating of material, with no over spray or residual build up of materials on down stream equipment. In such a system as much of the surface area of the pellet needs to be exposed to the spray as possible, in a contained environment, with enough time given for the liquid to be absorbed. The general criteria for the system would be the following:

Accurate ingredient metering

Uniform ingredient distribution

Liquid is absorbed into the pellet

Liquid and dry material is contained within the coating system

General considerations:

When using ingredients in any process it is necessary to examine the characteristics of the ingredient to insure that the method of controlling and metering the ingredient is appropriate. These characteristics include density, viscosity, pH, percent needed to apply, desired accuracy, and optimal temperature. Careful consideration should be given to the materials of construction and desired accuracy. For example it is undesirable for copper or copper alloys to come into contact with animal fat. Tallow has a tendency to solidify at higher temperatures so it is desirable to heat trace equipment used in the application of this ingredient. Feeders and pumps should be sized for the appropriate flow for the desired percentage of ingredient being applied. Make sure when sizing the pumps and meters that you consider the minimum threshold for a no flow condition. For example if there is no way to surge product going into the application system, then you may want to divert and ignore the material that comes from the cooler during initial start up when the flow rate is very low. When looking at various methods for metering and measuring the flow of material, make sure that you consider the ongoing cost as well as the upfront cost. There is a common misconception that if an ingredient is cheap, you can use a cheap method for measuring the ingredient because it doesn't cost much. If the ingredient is expensive, or if you use a large quantity of the ingredient, it can be shown that the more accurate methods of metering pay back quickly. For example if the volumetric meter that you are using has an accuracy of +/- 1% that means that in order to insure that enough of the ingredient goes into the product, you could be over formulating by 1%. It could also be true that a change in supplier or a change in the lot of ingredient that you have been using, or a change in the temperature, has caused a 1% error in the measurement that you are using, because the density of the product has changed, and you did not realize it. Lets suppose that you have a pellet line running at 60tph and you are

applying 5% fat to the pellet. The amount that you are applying is off by +1% of the desired flow. $120,000 \times .05 = 6000\text{lbs} \times .01\text{error} = 60\text{lbs/hr} \times 16\text{hrs per day} \times 300\text{ days} = 288,000\text{lbs per year} \times .4 \text{ for forty cents a lb} = \$115,200.00 \text{ per year}/12 = \$9600.00/\text{month}$. A coriolis meter that is .1% accurate will cost less than \$ 10,000.00 so the meter has paid for itself in about a month. It really pays to be accurate.

In order to make sure that all of the possible parameters are taken into account, a chart can be created that has the following information:

	Maximum	Minimum	Nominal	Density
Dry Flow Rate	_____	_____	_____	_____
Dry Material Particle Size	_____			
Dry Material Angle of Repose	_____			
Desired Accuracy	_____			

	Maximum	Minimum	Nominal	Density
Liquid Flow Rate	_____	_____	_____	_____
Liquid Operating Temperature	_____			
Liquid Viscosity at Operating Temperature	_____			
Liquid PH	_____			
Desired Accuracy	_____			

Product	Max. Flow	Min. Flow	Density or Specific Gravity	PH	Temp.
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Make sure that all of the ingredients are covered by the chart. Give each of the suppliers of equipment and each of the suppliers of ingredients the chart. This will insure that all of the people involved in the process are informed. It will also make sure that everyone is in agreement as to what the system requirements are.

In any application system there are two issues that must be addressed; method of application and control of metering. Most commonly the liquid application will take place at the pellet die or after the cooler.

Application at the Die

The addition of liquid immediately after the pellet process is quite popular. This method uses a spray nozzle or nozzles at the pellet mill discharge and typically uses volumetric measurement of the dry flow based on the number of turns of the feeder into the pellet mill. The liquid flow is either mass flow or volumetric.

The advantage of this type of system is that the liquid is being applied to the product as it is still hot from the pellet process. It is also inexpensive and can be installed on existing equipment.

The disadvantage to this system is that there is very little retention time for the liquid to absorb into the product. Even though the product is hot, time is still needed for the liquid to be absorbed into the product if the percentage of liquid is above 2 or 3 percent. When the percentage to be applied is higher, then the liquid can be drawn off of the surface of the pellet and end up in the cooler and the cooler air system. If the system is not cleaned at periodic intervals then the efficiency of the cooling system will be affected. Also the fines that are drawn off of the cooler are laden with fat, and if they are re-circulated back into the system then they can effect the formulation of the product and the ability of the pellet mill to make a pellet. The cooler also serves to pull moisture from the pellet. The application of fat or other oils on the surface of the pellet prior to cooling may change the coolers ability to remove water. These factors will affect the cooling of a green pellet and affect the pellet durability.

Modifications can be made in the duct work and cooler to facilitate cleaning. A regular schedule should be maintained in order to insure proper cooler operation. If the physical layout of the plant allows, a short conveyor can be added to increase retention time, and reduce the possibility of liquid being drawn off in the cooler. If the installation is a new one then a cooler can be chosen that will minimize the effect of liquid on the surface of the product. Because of the deeper bed depth and the lack of perforated pans, a counter flow cooler is more tolerant to this type of application. If an existing horizontal cooler is used then the perforated pans can be replaced with solid pans which will prevent plugging. A flow indicator at the pellet discharge will help to insure that we do not spray liquid when no dry product is flowing.

Common liquid applicators:

- Spray in a screw, ribbon, cut flight, paddle, conveyor
- Spray into a plenum or weir
- Spray in a rotating drum or reel
- Spray using a spinning disk

Spray into a batch mixer

Spray into a screw conveyor: (fig 1)



Many times spray nozzles are added to a screw conveyor to apply liquids to extruded product before packaging. Screw conveyors do not make good application equipment because they provide very little mixing action or retention. We can improve the performance of this type of equipment if we cut the flights or substitute ribbons for solid flights to achieve better mixing action. If we put paddles between the ribbon flights that are pitched to throw product back in the opposite direction of conveying then we have even better mixing action and retention. If we run the conveyor full it will stay cleaner and give us the maximum amount of retention and less breakage. The problem with this type of system is that the spray nozzles apply liquid on a relatively small portion of the product and count on the mixing action of the conveyor to disperse liquid onto the rest of the product. The dispersion of fats or oils can be done this way, but a water-soluble liquid like molasses can soak into the pellet almost immediately. This can cause spotty coverage where some of the product has a great deal of liquid applied and others have

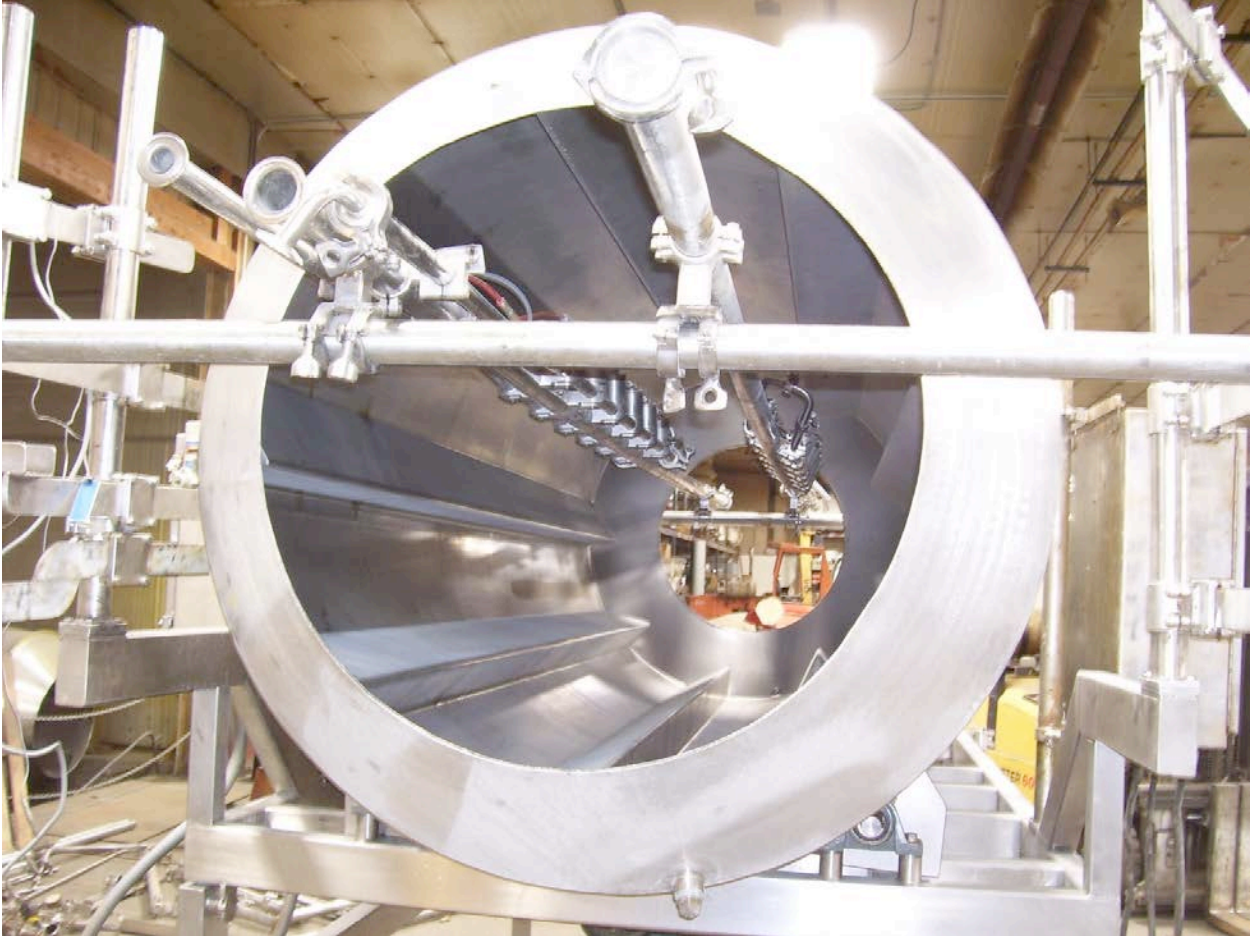
very little. One way to alleviate this problem is to drop the product into a plenum with spray nozzles prior to entry in a mixing conveyor.

Spray into a plenum or weir (fig 2)



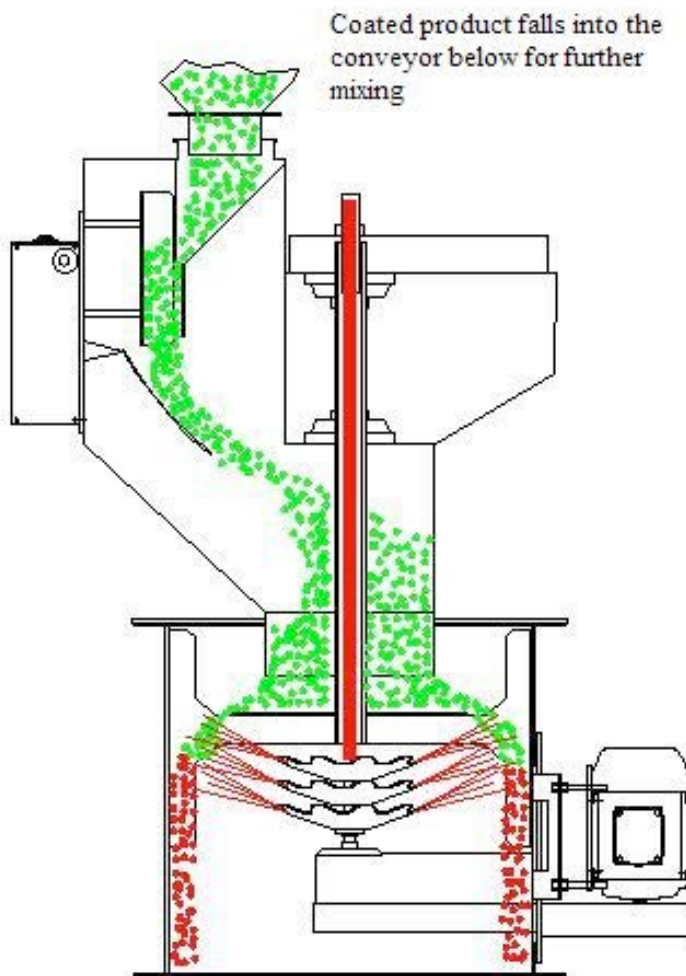
If we take the nozzles out of the mixing conveyor and arrange the nozzles on a chute, in a pattern for maximum coverage and easy cleaning. Then we can spray onto the product as it is tumbling in the air. This will greatly increase the efficiency of the mixing conveyor. By arranging pairs of nozzles on opposite sides we have better odds of hitting all sides of the pellet with spray. In the case of a weir the product is sprayed from one side, and then flipped over and sprayed on the other side. After the product gets the coating of liquid, it can then drop into a conveyor or drum to get more retention. This allows higher liquid addition rates more time to soak into the pellet.

Spray into a rotating drum: (fig 3)



The food and pet food industries quite often use a rotating drum with a variable angle of tilt on the drum. The product to be coated is discharged into the interior of the drum, which commonly has raised flights on the inside to tumble the product. The advantage of this type of system is that retention of the product can be adjusted. Also the drum eliminates pinch points that can cause product breakage so it is very gentle. The disadvantage of this type of system is that the drum is open on two ends and mist from the atomization of the liquid can migrate out of the drum and settle on the surrounding equipment. This type of system can also benefit by putting the spray nozzles into a plenum prior to entry into the drum.

Spray using a rotating disk: (fig 4)



Spray nozzles have a tendency to clog when applying liquids with suspended solids. Rotating disk applicators use two spinning disks to apply liquid to pelleted products, so spray nozzles are eliminated. Dry material is spun from a low RPM rotating disk and falls in a 360-degree curtain around a second disk. Liquid enters through the central bore of the dry disk shaft and drops onto the second disk spinning at a high RPM. The liquid is atomized into a fine mist that is driven by centrifugal force into the surrounding curtain of dry product. This results in a uniform coating of liquid without the need for spray nozzles.

This technology differs greatly from the traditional method of spraying, which would be to spray on a relatively small portion of the product and depend on the mixing action of a drum or conveyor to further distribute the liquid. Since the rotating disk applicator applies liquid as the product is falling past the liquid disk you are assured of having some liquid on all of the particles that pass by the liquid disk. These systems do incorporate a mixing conveyor, however the purpose of this conveyor is more for retention of the product, in order to give the liquid time to absorb into the product. Another obvious advantage of the disk applicator is that it does not require spray nozzles. This means that

any liquid capable of flowing through the delivery pipe is going to be able to flow through the machine.

This gives the user a great deal of flexibility in the selection of ingredients. Liquids that could previously not be used in coating systems because the high percentage of suspended solids clogged the spray nozzles easily pass through the spinning disk applicator. Since these machines are totally enclosed the over spray associated with open ended coating systems is eliminated. The top material disc spins at low RPM so the system is very gentle. The amount of liquid that the machine can apply depends on the hardness of the product and the porosity.

Spray into a batch mixer: (fig 5)



Another method to apply liquids is into a batch mixer. These systems are usually located just before load out or packaging. These mixers are typically fluidized zone mixers that use paddles or a combination of ribbons and paddles. These mixers work well because they are low shear and gentle on the product, but at the same time provide a very fast mixing cycle. This fast cycle time is necessary to keep the size of the mixer small, but still enable the mixer to keep up with the continuous flow of material. One advantage to this type of system is that a vacuum can be drawn on the mixer. The idea is that the vacuum draws the air out of the product and then when the vacuum is released the liquid is drawn into the product to replace the vacuum. This type of system allows for very high liquid addition by weight.

The advantage of this system is the high level of liquid that can be added. Another advantage is that the amounts of each ingredient are weighed. The disadvantage of this system is that it requires more headroom and is quite expensive.

Addition of dry ingredients: (fig 6)

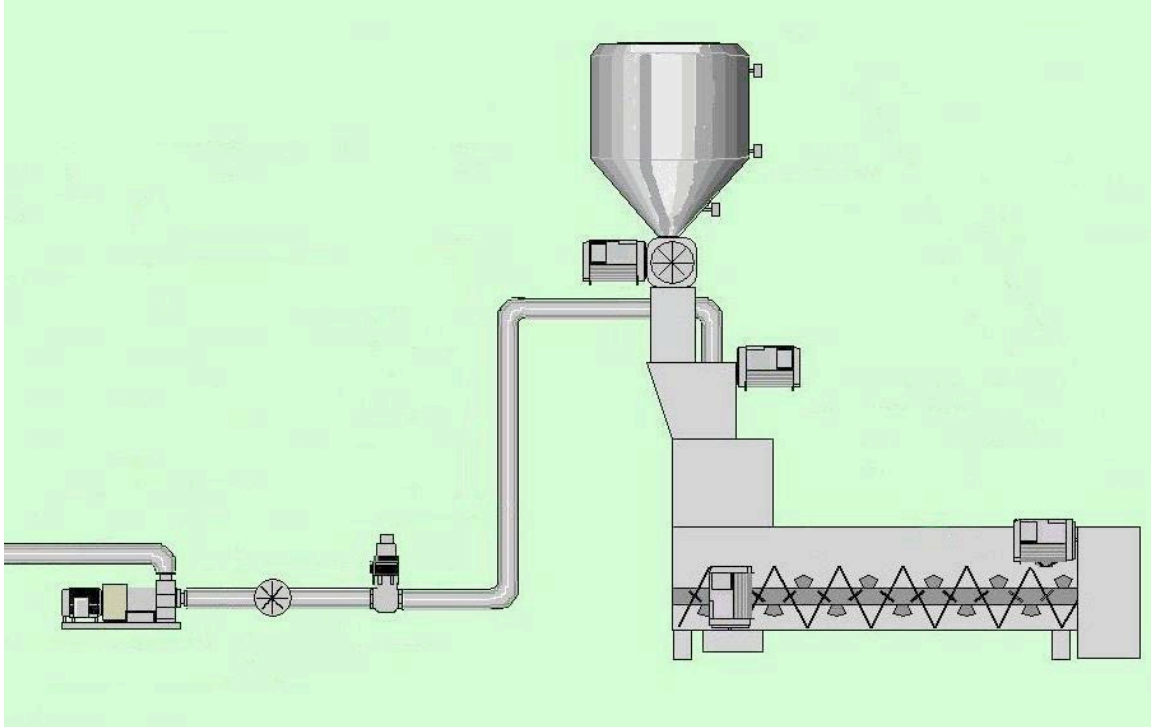


The most common way to apply dry ingredients after the pellet process is to meter the dry ingredients onto the particles after the application of liquids. This causes the dry ingredients to stick onto the particles. In order to apply a uniform tack application of dust to a particle the liquid must first be applied in a uniform fashion. The dry dusting should be applied just after liquid application before the retention time has given the liquid time to absorb on the particle. This can be done in any of the systems that we have looked at already. Another method for using dry ingredients is to blend the dry material with the liquids to be applied. Care must be taken that the ingredients are compatible and that the application system is capable of applying the solution or slurry. One common method for using a slurry application would be to have two liquid delivery systems, one for water soluble ingredients and one for oil soluble ingredients.

Control of metering:

The preferred method for achieving accuracy in the proportioning of ingredients into a process is by weight. The most accurate weighing processes are batch processes. This becomes problematic in the addition of ingredients after extrusion since these processes are continuous. The goal is to achieve a weight for the product, without interrupting the process flow. There are three principle methods for measuring the flow of material in a continuous flow. They are volumetric, mass flow, and loss in weight. In all of these methods we consider the flow of the carrier ingredients, in this case pelleted product, to be the master flow. All other additives are slaved from this master flow.

Volumetric (fig 7)



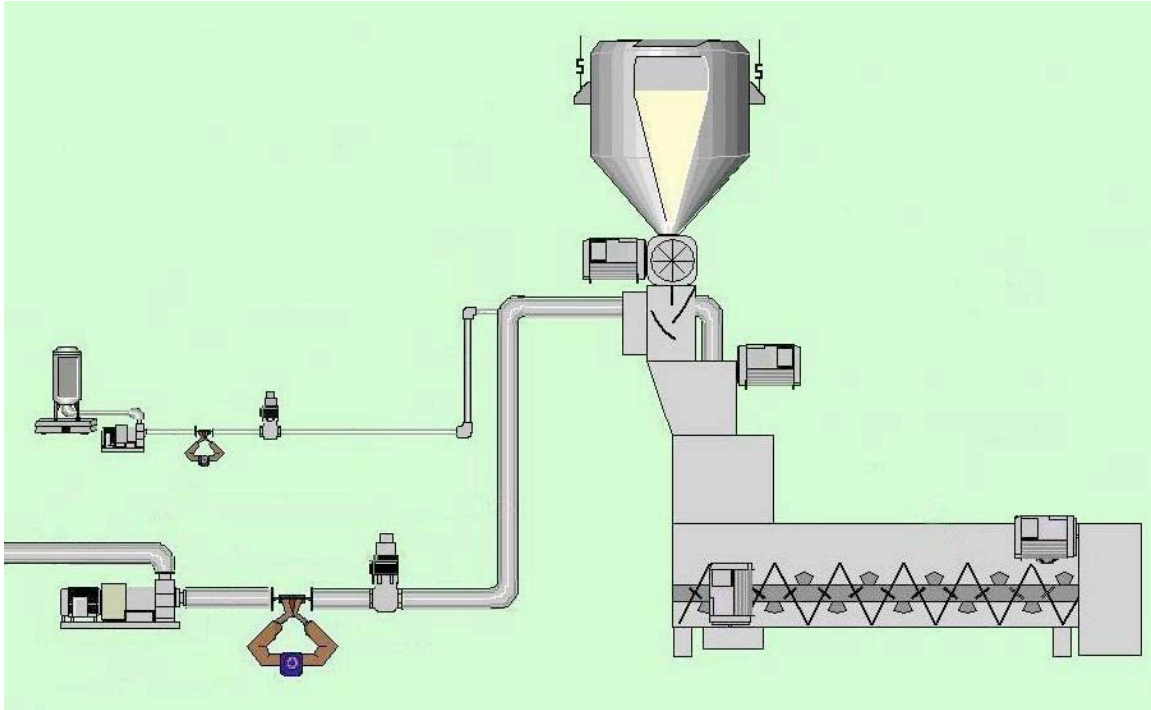
In volumetric metering the master flow of material is sensed by the number of revolutions of a screw conveyor, rotary feeder, or belt conveyor. We calibrate the material flow by measuring how much product has run through the system in a given amount of time. It is important to have a method to divert material from the process flow so that check weights can be done to confirm calibration.

The flow of liquid additives is sensed by the number of pulses we receive from a positive displacement liquid meter (nutating disk, turbine, or piston) or the number of revolutions that we see from a tachometer mounted on a positive displacement pump. If dry additives are to be added to the product stream then these are sensed in the same manner as the master flow.

The advantage of this type of system is that the up front cost is low and that the overall system is simple. This type of system works quite well if the density of the products never changes and if the formula of liquid to dry does not need to be frequently changed.

The disadvantage of this type of system is that it does not provide very good accuracy (1-2%). It also does not take into account changes in density or viscosity, so if the moisture or temperature of the product changes the system has to be re calibrated.

Mass Flow (fig 8)

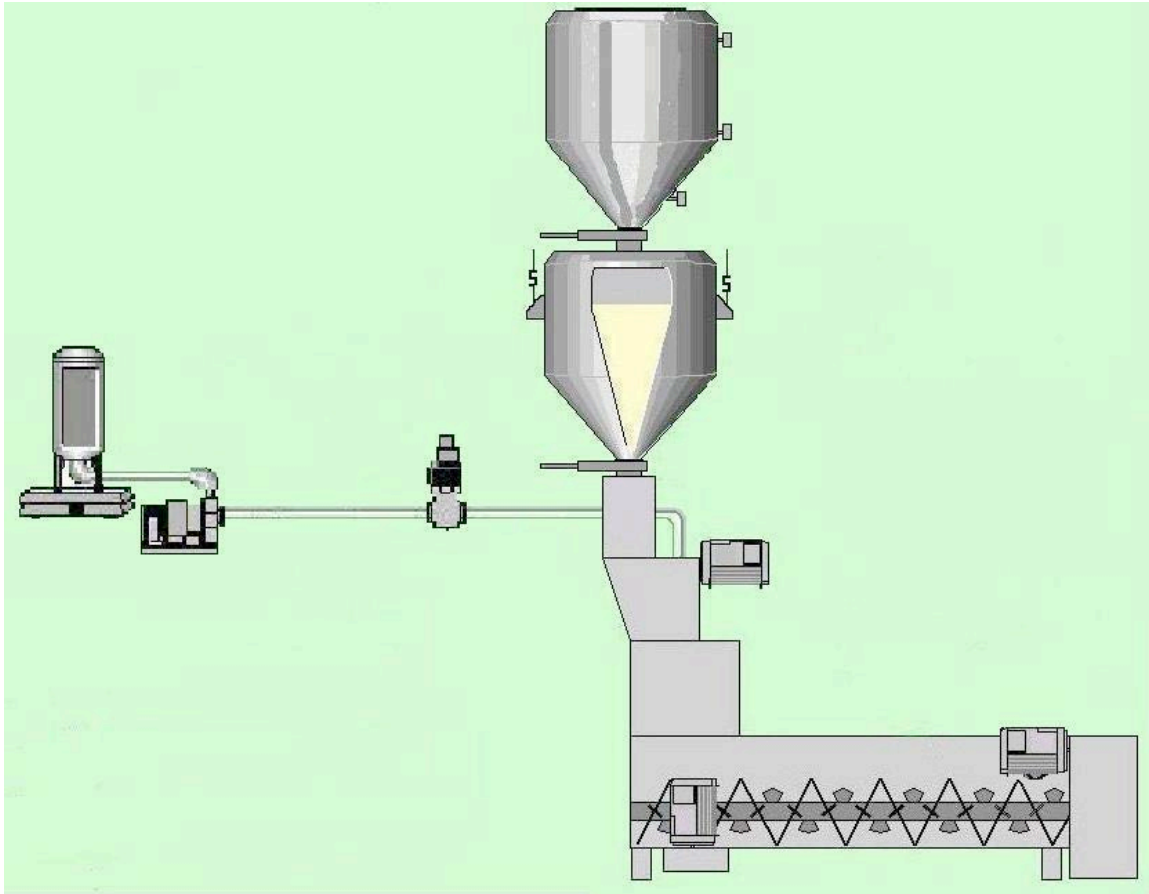


In mass flow metering the Master flow of product is sensed with a weigh belt, weigh feeder, impact scale, or centriflow meter. This type of measurement integrates the weight of the product with a tach signal from a conveyor or over a specified time period.

The preferred liquid meter in this case is a mass flow coriolis type meter. This meter measures a shift in frequency and position of a tube that is proportional to the mass flowing through the tube. This in turn tells us the mass of product flowing through a tube in a specified period of time.

The advantage of this type of system is that the measurement is unaffected by changes in density or viscosity. The accuracy is quite good (.5-1%) The disadvantage is the higher up front cost.

Loss in Weight (fig 9)



In loss in weight metering the master flow of product is sensed by monitoring the loss in weight of product flowing from a weigh hopper. In order to accomplish this type of weighing in a continuous flow application, a garner hopper must be used to surge product prior to entry in the weigh hopper. The system cycles drafts of product into a scale hopper and discharges the hopper at a rate that is used as the master flow. This flow is then used to signal a speed control on a positive displacement pump for proportional discharge of a loss in weight liquid scale.

The advantage of this type of system is that the actual weight of the product is being monitored so changes in density are accounted for. Also calibration of this type of system is simple, since local scale companies can check the system calibration.

The disadvantage of this type of system is that it requires a large amount of head room to accommodate the garner hopper above the loss in weight scale. The up front cost for this type of system is also greater than either of the systems mentioned before. However, if the number of ingredients being weighed is greater than three, then the cost can compare well with mass flow technology using coriolis type meters.

Micro Liquid Dosing

The principle that have been presented so far also apply to the metering of small liquid additives such as enzymes, anti-oxidants, mold inhibitors, and other micro additives. These ingredients are quite often temperature sensitive so the most common application

point would be after the pellet mill. There are also other considerations that are unique to small additives. Small additives are usually quite concentrated which makes the price per kilogram higher than most other ingredients. This increases the need to be accurate in the metering of not only the liquid or powder that is being applied, but also the accurate measurement of the pellet flow into the coating system. When these micro additives are going to be used, it is always best to use a system that takes the weight or at least the density into consideration. Since these ingredients can be applied at levels as low as 50grams per ton , it is usually not necessary to have a bulk storage and receiving system set up for these ingredients. These ingredients are usually received in plastic totes or drums so the pumping system should be designed to easily change out a tote or drum so that when one gets empty the next one can easily be brought on line for production. Most systems use another tote or small tank that allows some surge capacity so the main tank can be run empty without interrupting the flow. It is quite common for the storage tank to sit on a platform scale so that inventory reconciliation can be easily accomplished. These systems quite often have a transfer pump at the main tote in the warehouse that will pump ingredients to a dosing station close to the application point. This allows the temperature of the main storage tank to be more easily controlled by keeping the bulk of the ingredient in the warehouse, and not in the process area, where the temperatures can be significantly higher. A diaphragm, gear pump or other positive displacement pump can be used for these ingredients and they are rated in liters per hour instead of liters per minute. These micro liquid systems may also have a separate dilution system that is used to dilute the ingredients prior to the blending system. This helps spread the ingredients over more surface area and increases the mixing efficiency. When a dilution system is used, then it may be necessary to use a static mixer to premix the ingredients prior to blending. This is especially true when the carrier liquid is not compatible with the micro liquid. It is also important to establish a regular schedule for check out and inspection of the system so that any small leaks can be discovered before they become large leaks. Most micro liquid systems will also have a secondary containment system with a level detector, so if a leak does happen in the storage container or the immediate surroundings, an alarm will sound to alert the operator. As with the other ingredients that are added in a continuous stream, the system should be set up so that it can be easily checked for calibration. This means that valves or gates should be put in place to divert product so it can be weighed to confirm that the dry and liquid meters are correct.

Principle Components Common Problems /Recommendations
Pellet Feeder
Screw conveyor

Should be built with close tolerance to avoid breakage. Over sizing the conveyor also keeps the speed low and makes for less product on steel contact.

Belt Conveyor

Scrapers and brushes should be used to minimize fines carry over on to the back side of the belt. Belt alignment sensors should be used to make sure that the belt is serviced as soon as the belt starts to drift, otherwise the belt can be damaged. Auto belt tensioning should also be used. The bottom of the conveyor should be arranged so that product that carries over can drop out of the bottom of the conveyor, or be regularly cleaned out. If not, material can pack in the bottom and damage the belt.

Rotary Pocket Feeder

The inlet of the pocket feed should have a flex material to eliminate the pinch point where breakage can occur. Pockets should be staggered to avoid feeding the system with a surging flow.

Variable Slide Gate

Make sure the slide gate has high resolution and a linear response.

Pellet Meter

Weigh Belt

Design of the weigh belt should eliminate the build up of fines between the weigh bridge and the belt. Auto tensioning can eliminate the possibility of weights changing due to changes in belt tension.

Weigh Screw

Pivot point should have free movement. Flex should be material that does not shrink due to changes in temp. or moisture. Conveyor should be oversized to maximize material in the conveyor.

Impact Scale

Avoid excessive free fall into the impact scale (no more than 3ft or 1 meter). Special abrasion resistant materials should be used on the sensing plate. Should be cleaned and inspected on a regular basis.

Liquid Pump

Gear Pump or Progressive Cavity Pump

Make sure that contact surfaces are appropriate for the material that is being metered. Flood feed the inlet of the pump to make sure that the inlet is not starved. Use a dual basket strainer so the strainer can be cleaned without shutting down the pump. Make sure that the screen in the strainer has a large surface area to avoid having to clean too often. Set a maximum hz or rpm value in the control system so you know when the pump is starting to wear excessively.

Diaphragm Pump

Set up schedule for replacement of pump diaphragm according to manufacturers recommendation for number of hours use. Use a pulsation dampener and back pressure regulator to eliminate the pulsations from the diaphragm.

Centrifugal Pump

Use for refill applications. Most centrifugal pumps are not appropriate for metering because of internal slippage they lack repeatability and usually can not generate higher pressures.

Liquid Meter

Nutating Disk, Piston Meter, Gear Meter

Meter should be sized for max and min flow. If a large amount of solids is in the fluid a Nutating disk meter is more tolerant. Make sure the transmitter that is selected is compatible with the automation system. Make sure that the fittings that are supplied with the meter are compatible with the plumbing in the plant. Disk, Piston, and Gear meters are volumetric, so you can help the accuracy of the meter by keeping the liquid at a constant temperature.

Coriolis Meter

The coriolis meter is comprised of a u shaped tube, an electromagnetic drive coil, and two sensing coils. The u shaped tube is made to vibrate at a set frequency, usually around 80hz. This up and down vibration has a total movement of less than a tenth of an inch, and is stable when no fluid is flowing through the tube. When fluid flows through the tube, the direction of the fluid flow resists the up and down motion of the u shaped tube. As the fluid flows around the bend of the tube, the other side of the u shaped tube also resists the up and down motion of the tube. This resistance causes a twist in the tube and the sensing coils on either side of the tube pick up the difference between the two sides of the tube, and translate this into the degree of twist in the tube, which is directly proportional to the mass flowing through the tube. Coriolis meters have an accuracy range from .1% to .2% of the flow, within the meters rated flow capacity. This means if the flow rate that is called for is 10lbs per min. the flow out of the meter will be between 9.99 and 10.01 lbs per min. These meters are very stable so once the meter has been calibrated, they rarely go out of calibration. There are some guidelines that have to be followed in the installation of these meters. The meters should be mounted so that they are being supported by the pipe that is supplying the fluid to be measured. If the meter is ridgedly mounted on its own surface, separate from the pipe, then when the pipes move during expansion or contraction, the meter can be subjected to force that could damage the meter. If the weight of the meter causes the pipe to sag, then the pipe on either side of the meter should be supported. If the meter is to be located in an area where excessive vibration is present, then vibration dampening mounting adapters are available from most manufacturers. The vibration dampening is to protect the internal sensing elements, which could be damaged from long term exposure to excessive vibration. If a fluid such as tallow is being used, and the lines need to be heat traced, most manufacturers have trace kits that allow the meter to be electrically or steam heated. In many applications the lines into and out of the meter will be traced, and the residual heat is enough to keep the meter warm. In any case, the maximum temperature rating for the meter should not be exceeded (this is around 250 degrees F for the actual fluid temperature, with much higher temperatures available when specified). Most applications will have the sensing element mounted horizontally with the inlet and discharge pipes also running horizontally. If it is necessary to mount the meter vertically you need to make sure that the direction of flow is up through the meter, not down through the meter. The meter should always be kept full, so it is a good idea to have a short

vertical run after the meter, rather than discharging out of the end of a horizontal pipe.

Mixing Conveyor, Spray Plenum, Weir, or Rotating Drum

Spray Nozzles Plug

Make sure that the liquid is filtered through a basket strainer and that the filter is sized smaller than the smallest orifice opening on a spray nozzle. Make sure that the strainer arrangement is a dual basket strainer so that when the strainer is plugged it can be cleaned out without interrupting production.

Arrange the spray nozzles so that they can easily be replaced and swapped out. Some systems have dual spray bars so that while one system is being cleaned the other system takes over. Compressed air purging of nozzles is sometimes used as well as a solenoid actuated needle that periodically cycles in and out of the orifice.

Spray Nozzles Dribble

Many times spray nozzles are sized for the maximum flow and then when the minimum flow is tried there is not enough hydraulic pressure to get a good atomization. Again, the system should be arranged so that nozzles can be easily changed and swapped out, with one set of nozzles for high flows, and one set for low flows.

Over Spray of Liquid On Surrounding Area

One problem that is most common with a drum type coater is the problem of atomized mist migrating out of the drum and settling on the surrounding equipment. One way to alleviate this problem is to decrease the level of atomization. Often atomization of the liquid is accomplished by combining the flow of liquid with compressed air. The compressed air can cause too fine a droplet and will increase the possibility of the liquid becoming air born. When ever possible it is better to use hydraulic pressure rather than pneumatic pressure to atomize the liquid.

Build up of Liquid On Down Stream Equipment

Adjust angle of tilt on drum for more retention. Slow down mixing conveyors for more retention. Make sure that dry flow sensing threshold and sequencing is set correctly so that the liquid is being sprayed on to dry product flow.

Rotating Disk

Spotty Spray Coverage

Dry flow too low to cover dry disk. Liquid goes through gaps in the curtain of material and runs down into the mixing conveyor. Slow down dry disk until it is throwing a 360 degree curtain.

Conclusion

The type of system that is employed depends on the required accuracy of the ingredients and how expensive the ingredients are. Even though mass flow system and loss in weigh systems have a greater up front cost, a very short payback may be realized in eliminating the need to over apply an ingredient due to worst case errors. Regardless of which system is employed, regular cleaning, maintenance, and calibration of the system should be scheduled to insure accurate and trouble free operation.

Terry Stemler

